Collaborative Point Paper

On

Active Protection Systems

October 2006

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NATIBO Collaborative Point Paper
on
Active Protection Systems

1. **Introduction –** The North American Technology and Industrial Base Organization (NATIBO) fosters cooperative planning for technology and industrial base program development among and between the Defense Departments of the U.S. and Canada. The NATIBO objectives are to:

   - Promote the development, administration, communication, and execution of the U.S. Department of Defense (DoD) and Canadian Department of National Defence (DND) technology and industrial base programs and policies.
   - Foster cooperation between the Governments of the United States and Canada in development of coordinated technology and industrial base policies and programs.
   - Leverage resources through cost sharing and economies of scale afforded through coordinated studies and projects involving research, development, industrial capability, and logistics programs.
   - Promote the exchange of technology and industrial base data between Canada and the U.S., the military services, other government agencies, and industry.
   - Promote coordination of technology and industrial base planning and insertion programs undertaken by the responsible U.S. and Canadian departments and agencies in support of their national security responsibilities.
   - Ensure that North American technology and industrial base considerations are taken into account during U.S. or Canadian military and/or civilian emergency planning activities.
   - Enhance the national security of both nations by promoting the competitiveness of the North American technology and industrial base.

   A Memorandum of Understanding (MOU) between DoD and DND for North American Technology and Industrial Base (NATIB) Activities was signed on 30 May 2001. The MOU is an umbrella document that covers research, development, technical demonstration and technology insertion activity in the two Defense Departments. The MOU allows three basic activities: Information Exchange, the creation of Working Groups, and formal Project Arrangements (PAs). The MOU provides a legal framework for which funds can be transferred between the participants in support of NATIBO studies and projects.

2. **Definitions and Acronyms.**

   Definitions:
   Active Protection: For purposes of this study, active protection refers to those systems designed to acquire, track and respond to threats to specific platforms. Using this definition, armor is excluded.
   Platform: For purposes of this study, the platforms of interest are wheeled and tracked vehicles including Light, Medium and Heavily armored transport and combat vehicles.
   Countermeasures: Countermeasure are the response portion of the Active Protection system and can include expendables (chaff & flares), kinetic projectiles, and directed energy (microwave & laser).

Acronyms:

MOU	Memorandum of Understanding
NATIBO	North American Technology and Industrial Base Organization
PA	Project Arrangement
R&D	Research and Development
TOR	Terms of Reference

3. **Background.** Current deployments by US and Canadian forces have identified the need for improved protection from a variety of threats including Improvised Explosive Devices (IEDs) and Rocket Propelled Grenades (RPGs). These threats are aggravated given the increased use of medium and light duty vehicles not specifically designed for combat. Active Protection Systems (APS) are survivability concepts intended to provide protection either as a substitute for or in addition to massive, passive armors at only a fraction of the vehicle weight. Conceptually, an APS can improve survivability by defeating incoming anti-tank guided missiles (ATGMs), RPGs, tank-fired high-explosive antitank missiles, tank-fired kinetic energy (KE) rounds, indirect fire, and guided top-attack threats.

   Active protection system's components will include threat detection, tracking systems, signal processing systems, countermeasures systems and base armor, used for structural and residual threat defeat. A variety of sensors including radar, IR and laser detection systems will be employed on board the vehicle to provide the capability of detecting and tracking multiple munitions and directed-energy weapon threats. A typical sensor subsystem includes a threat warning, or cueing sensor, and a tracking sensor. The critical component of an APS is its countermeasure. Countermeasures include not only active protection, but electronic devices, obscurants, decoys, and other technologies for hit and detection avoidance. Upon detection of a threat, the system enables the vehicle commander to select the most appropriate countermeasure or defensive tactics to avoid a hit (when engaging anti-tank missiles or threats at medium/long range). The system automatically activates countermeasures, when necessary (primarily against high velocity missiles and kinetic energy threats or RPGs at short range. The optimal implementation of APS should be "design-dependent" thus, make it adaptable to a tracked or a wheeled vehicle as well as fixed positions. ***Attachments 1-3 provide detailed information regarding on-going technologies and products.***

4. **Purpose.** The purpose of a collaborative point paper is to: (1) provide information regarding a subject of interest to both defense departments, (2) identify on-going technology and procurement activities within that subject area, (3) identify subject matter experts and organizational representatives in both departments with responsibility for the subject area, and (4) advocate collaboration using either the NATIBO MOU or another appropriate agreement. The point paper uses, in part, the format for a NATIBO working group Terms of Reference (TOR) document to facilitate the establishment of a formal working group under the MOU.

5. **Objectives.** The primary objective is to establish collaborative efforts on Active Protection technologies, system development, demonstration/test, and deployment concepts. The collaboration could include, but not be limited to, studies on technologies or requirements, joint research initiatives, technology insertion demonstrations, vehicle integration, military ruggedization, component testing or operational concept development. The NATIBO website can be used as an initial reference source: www.acq.osd.mil/ott/natibo/

6. **Exchange of Information.** The information contained in this point paper an the attachments was obtained from public sources and can be distributed within both DoD and DND. If a formal working group is established, participating subject matter experts, may exchange information pertaining to relevant APS activities.

   A formal working group would ensure that any information provided in accordance with an approved TOR is used only by the participants and then only for the purpose for which it has been provided. Information will not be disclosed or released to any third party, including defense contractors, or used for any other purpose without the prior written consent of the providing participant.

7. **Legal Status.** Establishing a Working Group by having a signed TOR constitutes an administrative procedure to coordinate NATIBO activities between the Participants. It is not the intent of the Participants that this document be considered a legally binding document under international law. A TORby itself does not create any authority to perform any work, award any contract, exchange information, transfer funds, or otherwise obligate in any way either Participant to make or provide any financial or non-financial contribution to the other Participant for any purpose. Any collaborative activities identified for investigation by the Working Group would be pursued in accordance with the terms and provisions of the NATIBO MOU.

8. **Financial implications.** This document or an approved TOR creates no financial commitments regarding individual PAs. Detailed descriptions of the financial provisions for a specific project, including the total cost of the project and each Participant's cost share, will be contained in the specific PA.

Reference Material from “Defense Industrial Base Capabilities Study: Protection”, December 2004 published by DUSD(IP)

Requirements with respect to protection from Rocket Propelled Grenade (RPG) attack:

- Deny/Disrupt RPG attack by deflecting RPG with HE at long range
- Destroy RPG with fragmentation rounds (combined HE and fragmenting projectiles) at long range
- Destroy RPG with high velocity projectiles at long range
- Deny/Disrupt RPG attack by blinding shooter with lasers
- Destroy RPG with self fusing fragmentation rounds at close range
- Destroy (pre-detonate) RPG with forward firing catcher nets at close range
- Deny/Disrupt RPG target engagement with obscurants at medium range

Armor	
Armor is defensive coverings designed to physically shield personnel or equipment from attack. This area includes both active and passive technologies.	
♦ Advanced Explosive Reactive ♦ Electrified Anti RPG ♦ Lightweight Armor Materials ♦ Lightweight Communications-Integrated Helmet ♦ Liquid Personnel Armor ♦ Smart Armor ♦ Space Hardening and Shielding ♦ Transparent Armor	

Countermeasures

That form of military science that, by the employment of devices and/or techniques, has as its objective the impairment of the operational effectiveness of enemy activity. This broad technical area includes all precision guided weapon systems, electro-optical guided weapon systems, millimeter wave guided weapon systems, and related dispensable and non-dispensable countermeasures such as various flares, chaff, RF jamming, and sensor dazzling.

- Acoustic Towed Decoy
- Active Chaff
- Adaptive Track loops
- Advanced IR Target Discrimination Algorithms
- Air-Launched Decoys
- Air-to-Air Radar Jammer
- All Aspect and Shadow Shields
- Anti-Radiation Tether Retrofit
- Beamforming
- Cable-Based Magnetic Sweep Decoy
- Carrier Frequency Agility
- Catcher Netting
- Chaff
- Counter-IR Laser
- Counter-IR Multi-Band Laser
- Defensive Co-orbital "Escort" Sats
- Degausser
- Dialable Frequency Low-Power IR Transmitter/Jammer
- Dispersible IR Decoys
- Dispersible Kinematic Flare (AKA Smart Flare)
- Ejectable Obscurants
- Expendable Anti-Torpedo Acoustic Decoy
- Expendable RF Decoys
- Fiber Optic Towed Decoy
- Flares
- Gun-Launched Decoy
- Mobile, Re-Programmable Acoustic Decoy
- Non-Coherent Arc Lamps
- Nulling Antennas With Automatic Response
- Optical Limiters
- Optically-Generated RF Waveforms
- Plasma Antenna
- Radio Proximity Fuse Jammer
- Reduced RCS, Directional Laser IRCM System
- Selective-Reactive RF Jamming
- Self-Igniting Pyrotechnic Sources
- Ship-Launched Decoys
- Sidelobe Cancellation
- Space Frequency Adaptive Processing
- Space Launched Decoys
- Space Launched Radar Decoy
- Space LIRCM
- Spatial Temporal Adaptive Processing
- Supersonic Air Launch Kinetic Decoy
- Telescope Shades

Technology Suppliers [1]						
Company Name	Est.	Location	Employees	Sales (US$M)	Website	Technology / Line of Business
Countermeasures: Dispersible Kinematic Flare						
BAE North America	1999	Rockville, MD	25,000	$5,000.0	www.baesystems.com	Design, manufacture, and maintenance of military aircraft, submarines, surface ships, avionics, radar, electronics, and weapons systems
Chemring Countermeasures	1997	Wiltshire, U.K.	1,641	$47.3	www.chemringcm.com	Design and manufacture range of RF and IR decoy cartridges for airborne, naval and land
Esterline Technologies	1967	Bellevue, WA	5,500	$562.5	www.esterline.com	Elastomer products, ordnance, and military countermeasures
Kilgore Flares Company	1925	Toone, TN	375	$40.7	www.chemring.co.uk	Conventional IR decoys
Thales	1968	Cedex, France	71,309	$1,761.3	www.thalesgroup.com	Global electronics company providing search, detection, navigation, guidance, aeronautical, and nautical systems
Countermeasures: Mobile, Re-programmable Acoustic Decoy						
BAE Underwater Systems	1984	Waterlooville, U.K.	570	N/A	www.baesystems.com	Development and produce undersea guided weapons, unmanned vehicles, mine warfare systems and diver reconnaissance aids
Northrop Grumman	2000	Los Angeles, CA	122,600	$26,206.0	www.northropgrumman.com	Defense prime contractor and systems integrator
Office of Naval Research (ONR)	1946	Arlington, VA	N/A	N/A	www.onr.navy.mil	Coordinate, execute, and promote the science and technology programs of the US Navy
Rafael Underwater and Surface Warfare Systems	1948	Haifa, Israel	5,000	$804.3	www.rafael.co.il	Defense R&D of microelectronics, communications, acoustics, and propulsion
Sensytech, Inc.	1998	Newington, VA	220	$53.2	www.sensytech.com	Manufacture electronic high frequency communications systems and components
Countermeasures: Plasma Antenna						
ASI Technology	1999	Henderson, NV	3	$0.0	www.asiplasma.com	Development and commercialization of plasma technologies
Defence Science and Technology Organization	1910	Melbourne, Australia	N/A	N/A	www.dsto.defence.gov.au	Australia's government defense research facilities
Haleakala Research & Development	2002	Brookfield, MA	2	$0.1	www.haleakala-research.com	Develop plasma smart antennas
Markland Technologies	2002	Ridgefield, CT	30	$10.0	www.marklandtech.com	Biometric devices and security systems integration
ONERA (French Aeronautics & Space Research Center)	1946	Chatillon, France	1,850	$125.4	www.onera.fr	Aircraft, spacecraft and missile design
Plasma Antennas Ltd.	2000	Oxford, England	4	$0.0	www.plasmaantennas.com	Plasma antennas
Countermeasures: Plasma Antenna - Non-Metallic Substrates						
Antenova	1999	Cambridge, U.K.	33	$0.0	www.antenova.com	Design and manufacture antennas
Honeywell Electronic Materials	1961	Sunnyvale, CA	N/A	N/A	www.honeywell.com/sites/sm/em	Develop and manufacture chemicals and specialty materials used in the production of semiconductors
Isola Laminate Systems Corp	1945	Chandler, AZ	2,200	$169.4	www.isola-usa.com	Manufacture base materials for circuit boards
Kyocera Corporation	1959	Shiga, Japan	57,870	$10,969.4	www.kyocera.com	Manufacture components and fine ceramic products for the electronics industry
M/A-COM	1950	Lowell, MA	3,000	N/A	www.macom.com	Develop and manufacture radio frequency (RF) and microwave semiconductors, components and IP network solutions
Microface Co., Ltd	1999	Gyeonggi-do, Republic of Korea	N/A	N/A	www.mface.com	High-end and technically advanced antenna

ATTACHMENT 2

MLMT/Industrial Base Information Center*
2310 8th Street, Room 109 **Phone: 937.255.2505**
Bldg. 167 **Fax: 937.255.6267**
WPAFB OH 45433-7801

IBIC appreciates any comments or suggestions regarding our products

IBIC Project 06-025

DATE: 08 Aug 06

PROJECT SUMMARY MEMORANDUM

SUBJECT(s):	**VEHICLE PROTECTION ANALYSIS FOR NATIBO**
REQUEST DATE:	**01 Aug 06**
CUSTOMER(s):	**North American Technology and Industrial Base Organization (NATIBO)**
IBIC OPR:	

INFORMATION REQUESTED:

The customer requested help scoping a NATIBO project about active protection of vehicles from Rocket Propelled Grenades (RPGs) and/or Improvised Explosive Devices (IEDs). Specific information requested includes identification of companies that provide systems/products/technologies already in use and/or have planned/future systems/products/technologies or concepts that relate to the NATIBO project. The report is not to include company profiles, company financials, or data from IED study underway by pentagon agency.

FINDINGS/COMMENTS:

Findings

Various sources Jane's, Global Security, Defense Update and others identified several potential companies. The IBIC identified 26 major companies providing a variety of APSs and APS components. Of the 26 companies 17 are foreign owned.

Section 1of this report provides background information regarding vehicle active protection. Sections, 2 and 3 describe various APSs, including their functionality and major components. Section 4 contains APS/products/services not discussed in the previous sections

Section 1: Background

- The face of modern warfare has changed. Landmines, Improvised Explosive Devices (IEDs) and Rocket Propelled Grenades (RPGs) are the weapons of choice for terrorists and other enemy combatants. Troops face these threats around the clock with equipment never intended, nor designed, to withstand these weapons and their proliferation around the world.
- In the continuing conflict in Iraq, IEDs have become the single most significant threat to U.S. forces deployed in Iraq and Afghanistan. Constantly adapted in size, fuzing, and techniques of employment, they are the primary source of US casualties, both wounded and killed in action.
- Also, in Iraq shoulder fired anti-tank (RPGs) were once again proven a potent weapon. RPGs performed impressively in all post WWII conflicts, especially in Vietnam, Afghanistan and Chechnya.

US Government Agency Involvement

- On 22 Nov 05 the National Institute of Justice (NIJ) sought concept papers that will enhance the ability of law enforcement personnel in dealing with the threat of Improvised Explosive Devices (IEDs) and Vehicle Borne Improvised Explosive Devices (VBIEDs). The NIJ is the research, development, and evaluation agency of the US Department of Justice. NIJ provides objective, independent, evidence-based knowledge and tools to enhance the administration of justice and public safety.
- The reissuance of Department of Defense (DoD) Directive 2000.19, dated Feb. 14, 2006, changes the name of the Joint Improvised Explosive Device Defeat Task Force to the Joint Improvised Explosive Device Defeat Organization (JIEDDO). It also reissues DoD Directive 2000.19 dated June 27, 2005 to establish the JIEDDO as a joint entity and jointly manned activity of the DoD. The directive also designates the secretary of the US Army as the DoD Executive Agent (EA) of JIEDDO). Over Fiscal Years (FYrs) 2004 and 2005, the JIEDDO has spent over $2.73 billion to research, procure and operate counter IED technologies for the forward deployed forces.
- The Technical Support Working Group (TSWG) is the US national forum that identifies, prioritizes, and coordinates interagency and international research and development (R&D) requirements for combating terrorism. The TSWG rapidly develops technologies and equipment to meet the high priority needs of the combating terrorism community, and addresses joint international operational requirements through cooperative R&D with major allies. The Improvised Device Defeat (IDD), TSWG Subgroup delivers advanced technologies, tools, and information to increase the operational capabilities of the US military Explosive Ordnance Disposal (EOD) community and federal, state, and local bomb squads to defeat and mitigate terrorist devices. In collaboration with military, federal, state, and local agencies, the IDD subgroup identifies, validates, and prioritizes multi-agency user requirements through an ongoing generation and prioritization process.
- The US Army Tank-Automotive Research, Development, and Engineering Center (TARDEC) leads the US Army Active Protection Program, with technology development efforts provided by the US Army Research Laboratory (ARL), the US Army Armament Research, Development, and Engineering Center (ARDEC), and industry. Active protection systems (APSs) are being researched for application as a primary survivability component for the US Army's future combat system
- Recent Actions: The Marines have contracted EFW Inc. in TX and Netline & Elbit in Israel for the Hunter VHP CIED Program. Also, General Dynamics Armament and Technical Products (GDATP), Burlington, VT is contracted by the Marine Corps Systems Command's for the Chameleon Electronic Countermeasures (ECM) system. GDATP signed an exclusive teaming agreement (per FAR 9.6) with **Med-Eng Systems (MES) of Ottawa, CN**, for their active technology by establishing a framework of cooperation for the development, production, training and support for the Chameleon ECM CIED System. Under the teaming agreement, MES, Plexus Corp. Neenah, WI and Applied Marine Technology, Inc. Hanahan, SC will serve as subcontractors to GDATP for the Chameleon ECM CIED System.
- The Army has a contract with **Syracuse Research Corp.** in NY that developed the reactive technology and Telephonics Corp. in NY to increase production capability for the CREW II now know as the Warlock Duke program. The Army also has a contract with Canberra-Aquila and Delta Electronics in NM and Raytheon Technical Services in IN for the H2K & mICE Program.

Active Protection Systems (APSs) for Vehicles

Active protection systems are survivability concepts intended to provide protection to armored vehicles that equals or exceeds that of massive, passive armors at only a fraction of the vehicle weight. Conceptually, an APS can improve survivability by defeating incoming anti-tank guided missiles (ATGMs), RPGs, tank-fired high-explosive antitank missiles, tank-fired kinetic energy (KE) rounds, indirect fire — including bomblets and mortars, and guided top-attack threats. Vehicle armor must still provide protection against threats that cannot be addressed by the APS. These threats include small arms, mines and explosive fragments, including the residual shrapnel effects resulting from an active protection engagement.

The operational concept of active protection requires the application of advanced sensor, data processing, armor, and weapon technologies as an integrated system on the vehicle. Active protection system's components will include threat detection, tracking systems, signal processing systems, countermeasures systems and base armor, used for structural and residual threat defeat.

A variety of sensors including radar, IR and laser detection systems will be employed on board the vehicle to provide the capability of detecting and tracking multiple munition and directed-energy weapon threats. A typical sensor subsystem includes a threat warner, or cueing sensor, and a tracking sensor. The threat warner identifies a threat and then, through data processing, hands it over to the tracking sensor. The tracking sensor then determines the incoming threat's size, shape and vector. Signal and information processing technologies use the tracking data to enable the selection of countermeasures automatically or by the vehicle commander, calculate the firing solution and deploy the countermeasure.

The critical component of an APS is its countermeasure. Countermeasures include not only active protection but electronic devices, obscurants, decoys, and other technologies for hit and detection avoidance. Upon detection of a threat, the system enables the vehicle commander to select the most appropriate countermeasure or defensive tactics to avoid a hit (when engaging anti-tank missiles or threats at medium/long range). Or, the system automatically activates countermeasures, when necessary (primarily against high velocity missiles and kinetic energy threats or RPGs at short range.

The development of an enhanced commander's decision aid (CDA) is being pursued, for optimal utilization of the new defensive measures. Such systems will feed from the vehicle's sensors, as well as from off-board data sources, and will rapidly process the information, classify threats and recommend appropriate countermeasures.

Active Protection Systems commonly consist of an array of soft- and hard-kill techniques.
Soft-kill methods, similar to Electronic Counter-Measures (ECM) in aircraft, seduce and confuse an incoming missile, by using decoys, smoke and electro-optical signals, infrared or laser jamming.

Other concepts, which include "Hard-kill" techniques, are designed to intercept and destroy the incoming projectile or missile before it hits its target. Countermeasures include fragmentation charges, steel bars, high-pressure shock waves that will destroy the threat, destabilize or disrupt its flight path, or divert it from its course. Various types of munition countermeasures are currently under development. Such munitions include both explosive, fragmentation or Multiple Explosively Formed projectile (Multi EFP) based warheads, or hard metal bars (momentum-transfer armor). Other concepts include blast effect for the deflection of incoming penetrator rods, and deployment of "birdcatcher" nets, against top-attack munitions, which will intercept or disrupt their operation before they are activated.

The optimal implementation of APS should be "design-dependent" thus, make it adaptable to a tracked or a wheeled vehicle as well as fixed positions.

The following sections, 2 and 3 describe various APSs, including their functionality and major components. Section 4 contains APS/products/services not discussed in previous sections.

Section 2: APSs for Vehicles as Identified by Global Security and Defense Update

Global Security is the leading source of background information and developing news stories in the fields of defense, space, intelligence, WMD, and homeland security. Launched in 2000, GlobalSecurity.org is the most comprehensive and authoritative online destination for those in need of both reliable background information and breaking news. Global Security is well-respected, trusted and often-referenced in the media, both domestically and internationally.

Defense Update an online bi-monthly defense magazine is published in the United Kingdom. Highlighting evolving trends in Net Centric Warfare, defense electronics, Homeland Security, Special Operations, Counter-terror and Force Protection, Defense Update is recognized as a reliable source of updated information among international decision makers.

The APSs in this section include:

1. Close-in Active Protection System (CIAPS)
2. Full Spectrum Active Protection (FSAP)/Close-In Layered Shield (FCLAS)
3. Integrated Army Active Protection System (IAAPS)

Tables 2-1, 2-2, 2-3 included with their respective APS identify the companies and a brief description of the products/services, technologies or concepts they provide or are developing that relate to vehicle protection from RPGs and/or IEDs. Words in blue indicate hyperlinks to more detailed information.

Close-in Active Protection System (CIAPS)

The system consists of a radar staring in all directions that can detect an incoming threat at very short range and launch one of an array of pre-positioned interceptors to intercept and destroy the threat shaped charge warhead before it hits the protected vehicle. It is effective against anti-tank guided missiles (ATGMs) as well as rocket-propelled grenades (RPGs) and can defeat threats launched from very short range.

Fiscal year 2003 funding for the CIAPS supports a demonstration consisting of RPGs and ATGMs that are flight tested against a CIAPS prototype mounted on a testbed Light Armored Vehicle.

In fiscal year 2005, the Army demonstrated that a prototype CIAPS mounted on a light armored vehicle could defeat rocket propelled grenades (RPGs).

In 2005, United Defense disclosed that CIAPS could actually be a predecessor of the Close-In Counter-Measures (CICM) System, which became a derivative of the Integrated Army Active Protection System (IAAPS).

Table 2-1. Companies that provide CIAPS Products/Services

Company	Products/Services/Technologies Description
OptiMetrics, Inc. 3115 Professional Drive Ann Arbor, MI 48104 Tel. 734/973-1177	OptiMetrics, Inc. currently provides System Engineering and Technical Support The company possesses unique knowledge and expertise, in active protection technologies (systems of sensors and countermeasures to defeat incoming threats), and supports system engineering activities, including: • Trade-off assessments of APSs utilizing a range of high to low fidelity simulations• • Engineering evaluations of competing technologies • Modeling/simulations of sensor and countermeasure components • Test planning, coordination, and execution • Procurement of special test devices • Strategic program management and planning

Full Spectrum Active Protection (FSAP)/Close-In Layered Shield (FCLAS)
FSAP is a new active-protection concept currently developed for the US Army for its future and current armored vehicles.

FSAP is intended to be a "leap-ahead" capability in combat vehicle survivability to effectively defeat all known anti-armor threats within the "hemisphere surrounding the vehicle.
The system detects, tracks, intercepts and physically defeats large-caliber threats at a distance sufficiently far from the defended vehicle to reduce the lethal effects of the threat and assure vehicle survival. The development of a CDA is being pursued under FSAP.

A subset of FSAP is the Close-In Layered Shield (FCLAS) FCLAS, is a US Army Tank-Automotive Research, Development, and Engineering Center (TARDEC) led vehicle countermeasure project executed in conjunction with the US Special Operations Command and the US Department of Energy.

FCLAS will defeat RPGs, small ATGMs, Dual Purpose Improved Conventional Munitions (DPICMS) referred to as Explosive Remnants of War (ERW); smart mines, man-portable stinger-class munitions and high-energy antitank rounds from recoilless rifles.

The FCLAS countermunition is a 6-pound round to defend Army vehicle crews. The Close-In Layered Shield complements a long-range system or can be used as a stand-alone system. Within half a second, it conducts surveillance and target acquisition, tracks the threat, and launches, fuses and detonates the countermeasure to defeat the incoming threat.

The new shield is a cross-technology solution integrating countermeasure, radar, digital signal processing and explosives in a small, safe self-contained assembly. It is easily integrated into existing, fielded smoke-tube launchers or TARDEC-designed programmable launchers. Additionally, it would prove beneficial to other services and federal agencies.

Table 2-2. Companies that provide FSAP/FCLAS Poducts/Services

Company	Products/Services/Technologies Description
Northrop Grumman Corp (NG) Electric Systems Azusa, CA.	On 8 Nov. 2002, NG was awarded a contract for development and upgrading of their patented sensor. The objective of this effort is to deliver a demonstrated FCLAS system which provides close in hemispherical protection for ground combat and tactical vehicles, fixed installations, rotary wing aircraft and small watercraft. Work to be completed by Nov. 30, 2006.
Archangel Defense Systems This company is no longer registered with Central Contractor Registration **(CCR).**	In a 2002 topic, Defense Update announced an FCLAS system manufactured by Archangel Defense Systems. 

Integrated Army Active Protection System (IAAPS)
Future Combat System (FCS) vehicles are to be fielded with the IAAPS, a device designed to offer both "hard" active defense by physically intercepting incoming projectiles and "soft" active defense through the use of electronic countermeasures.

This program integrates and demonstrates advanced survivability equipment and computer programs for hemispherical protection of ground combat vehicles. Detailed trade studies of all survivability technologies conducted under this program support Department of the Army selection and approval of an optimized suite of survivability equipment for ground vehicle application.

All design options are open for the AP components in the hit avoidance suite, to include multiple systems for short-range and long-range protection or a single system that could provide protection at all ranges. There will be an initial concentration on technologies to defeat the very close range launch of small munitions.

In 2005, Defense Update disclosed that CIAPS could actually be a predecessor of the Close-In Counter-Measures (CICM) System, which became a derivative of the Integrated Army Active Protection System (IAAPS).

Table 2-3. Companies that provide IAAPS Poducts/Services

Company	Products/Services/Technologies Description
OptiMetrics, Inc. 3115 Professional Drive Ann Arbor, MI 48104 Tel. 734/973-1177	Currently provides System Engineering and Technical Support OptiMetrics, Inc. possesses unique knowledge and expertise, in active protection technologies (systems of sensors and countermeasures to defeat incoming threats), and supports system engineering activities, including: • Trade-off assessments of Active Protection Systems utilizing a range of high to low fidelity simulations• • Engineering evaluations of competing technologies • Modeling/simulations of sensor and countermeasure components • Test planning, coordination, and execution • Procurement of special test devices • Strategic program management and planning
United Defense **BAE completed its acquisition of United Defense on 24 Jun 2005**	CICM A derivative of IAAPS developmental countermeasures system, was optimized for close-in defense, was developed by United Defense in 2004, as a near-term countermeasure against RPG threats encountered in Iraq. The CICM System uses passive cueing sensors (flash detector) and low-cost tracking radar to detect and acquire potential threats at close ranges.

Section 3: APS Products/Services as Identified by Defense Update

This section describes various APS products/services for vehicles as presented by Defense Update topics and their review of Eurosatory 2006.

Defense Update an online bi-monthly defense magazine is published in the United Kingdom. Highlighting evolving trends in Net Centric Warfare, defense electronics, Homeland Security, Special Operations, Counter-terror and Force Protection, Defense Update is recognized as a reliable source of updated information among international decision makers.

Considered as the world's leading exhibition for land and land-air defense equipment, Eurosatory 2006 presented an impressive demonstration of the latest land forces systems and technologies.

Table 3-1 contains companies that provide APS products and/or services as presented by Defense Update topics. Words in blue indicate hyperlinks to more detailed information.

Table 3-1. APS Products/Services as presented by Defense Update

Company	APS Products/Services Description
KBM- Russia The Arena system has been developed by the KBM design bureau in Kolomna, Russia. For the export market the system is referred to as Arena-E.	Arena-E The system is designed to protect the tank from attacks of ATGMs launched from the ground and by attack helicopter and lightweight anti-tank grenades (such as RPG).  *Arena E Active Protection System installed on T-80U*
KBP - Russian	Drozd-2 The first and probably the world's only operationally deployed APS was the 1030M Drozd (Thrush), which was first installed on a T- 55AD MBT in the1983s.  The system is capable of defeating ATGMs and RPGs, approaching at speeds between 70 to 700 meters per second. The system employed eight 107mm anti-missile rockets, triggered by a pair of millimeter-wave radar sensors mounted on either side of the turret facing forwards. This configuration utilized the turret traverse to slew the protective devices into position. The rockets use time delay fuzing to activate a fragmentation charge at a safe distance from the tank. It is assumed that each radar sensor and rocket quad covers 40 degrees of the frontal arc. With an elevation of -6 +20 degrees. The rockets can be fired at any direction the turret points at, and rely on the radar for early warning, target detection and intercept parameters (speed and direction). The system is currently offered for the upgraded version of the T-80U, and is also proposed for the "Black Eagle" project.

Table 3-1. APS Products/Services as presented by Defense Update (Continued)

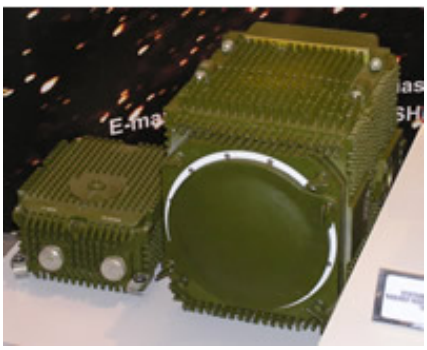
Company	APS Products/Services Description
Electromachina JSC, Russia	Shtora-1 Shtora-1 uses a laser warning device operating in the 0.65-1.6 micron range, comprising of an array of coarse (photo right) and fine resolution sensors, mounted externally on the turret. The system can automatically slew the turret and gun at the direction of the threat, to optimize the deployment of a thermal smoke screen or activation of active protection systems.  The sensor detects laser illuminating and alerts the crew and defensive systems. The warning display provides the commander and gunner with threat warning cueing. The display also provides jammer and countermeasures status indication. Countermeasures can employ an 81mm thermal instant smoke grenade, which deploy an instant smoke screen at a range of 50-80 meters from the tank, within 1.5 - 3 seconds. The system also employs a pair of electro-optical jammers, designated TShU1-7, which "hijacks" the missile's command link by feeding the tracker with modulated signals that cause the missile to deviate from its course, and away from its intended target.  A typical deployment of IR jammer can be seen on the Russian T-90, which mounts the Shtora-1 Defensive Aids System (DAS) shown on picture, with Kontakt5 ERA modules (left). The system protects the tank against ATGMs, using both the semi-active command to line of sight (SACLOS) guidance, by an IR source that mimics the flare on the back of missiles, as well as laser beam riders and laser-homing weapons.
JD-3 **The Chinese opted to equip their new Type 98 with a different countermeasure suite, based mainly on defeating ATGM, by the use of directed high power laser.**	Laser Dazzler The JD-3 “Dazzler” system comprises laser warning devices, a dome shaped sensor installed on the turrets roof-top, and a box shaped Laser Self Defense Weapon (LSDW) which “fires” a laser beam at the illuminating source, either a tank gunner, helicopter or missile launcher. The system employs two modes of operation – the low power mode is used at the general direction of the threat, in a search pattern designed to locate the target’s optics. Once locked on a target, the laser switches to high power mode, to defeat the target by blinding the operator or saturating its electro-optical circuits.

Table 3-1. APS Products/Services as presented by Defense Update (Continued)

Company	APS Products/Services Description
Diehl **Germany**	AWiSS Active countermeasures are developed in Germany by Diehl,  The system is designed as a lightweight suite, adaptable for the protection of heavy and light vehicles.
Krauss Maffei Wegmann and EADS Prototype system is currently under development under a technology evaluation of the Federal office of Defense Technology & Procurement (BWB)	Multifunction Self Protection System MUSS The prototype system is currently under development. During the test phase, the system was mounted on a Leopard 2 tank which successfully defended itself against various missile threats. MUSS weighs 65 to 160kg, depending on the equipment application, uses a combination of four sensors each covering an arc of 95x70 degrees, with a resolution of +/- 1.5 degrees. The sensors employ UV missile launch signature and laser detectors. When a threat is detected, the system responds within 1 – 1.5 seconds activating a smoke screen or directing infrared jamming signal toward the launching platform. During testing integration of the MUSS was designed for BOXER, FENNEK, and PUMA vehicles, as well as the Leopard 2A5 tanks 

Table 3-1. APS Products/Services as presented by Defense Update (Continued)

Company	APS Products/Services Description
GIAT Industries GIAT is developing a modular countermeasure kit designed for mounting on modern armored fighting vehicles	KBCM The system utilizes the DAL laser warning system and DDM missile launch detection system, smoke countermeasures and electro-optical IR jammer modulated to jam the missile operator's deviation sight. The system is considered for mounting on Leclerc and AMX-30B2 tanks, AMX-10RC and VBCI APCs 
The French Department of Defense has awarded a technical evaluation study and R&D contract to **GIAT, Thales and the Institute de Saint Louis** to develop an active defense system for French future armored vehicles	SPATEM The system is designed to detection threats at a distance of 50 meters, by electro-magnetic and IR sensors. Upon detection of a threat, the system launches a Rampe splinter charge, detonated at a close proximity to the incoming threat, destroying it at a distance of at least five meters from the protected platform. The system is scheduled for demonstration by 2006 and subsequently will be installed on Leclerc and AMX-30B2 tanks, AMX-10RC and EBRC APCs.  The French Leclerc utilizes some of the most advanced protection suits, including advanced hybrid armor applied to the turret and hull, threat warning systems and countermeasures and active defensive systems.
Israel Military Industries (IMI)	Pedestal Operated Multi Ammunition Launching System - POMALS This platform is designed to deploy countermeasures with high directional accuracy. Two pedestals, one on each side of the vehicle, provide 360 degrees protection using only two "grenade hives" that can store various payloads such as flares, decoys, smoke charges or fragmentation charges. POMALS has a multi-salvo capability, to enable activation of multi-level countermeasures, such as thermal smoke, or Quick Shield flares (also produced by IMI), these obscurants provide continuous protection from ATGMs, for up to 100 seconds. POMALS can be activated by a laser warning device, which provides immediate and automatic traversing of the launchers to point at the direction of the incoming threat. The system can also accommodate the Violin Mk-1 IR jammer.

Table 3-1. APS Products/Services as presented by Defense Update (Continued)

Company	APS Products/Services Description
RAFAEL, Israel Developed by Rafael Armament Development Authority Ltd., Thor is now available for sale and integration in the US by General Dynamics-OTS	Thor The system is modular and can be installed on a variety of vehicles and weapon stations, as an add-on system. The system is already operational is used by Combat Engineering and EOD/IED Defeat Forces, to enable on-the-move removal of explosive obstacles such as IEDs, mines, UXO and others, with embedded self-protection capability.
General Dynamics (GD) Land Systems - Canada	TROPHY Active Defense System (ADS) After evaluating several systems available in the world market, GD selected the system for further improvement. GD plans to introduce the system with every new and existing combat vehicle it produces, and is offering a version of the system to the US Army and other customers.

Based on a system designed in Israel by an industry consortium headed by RAFAEL (system), including Israel Military Industries (IMI) and Israel Aircraft Industries (IAI)- Elta (threat detection**).** The system is in full-scale engineering phase for inclusion on Merkava Mk. 4 tanks and the light armored vehicle (Stryker) In November 2000, following an international competition, the US Army Tank Automotive and Armament Command selected the now General Dynamics Land Systems - Canada LAV-III (8 × 8) (Light Armored Vehicle - III) to meet the US Army requirement for a Medium Interim Armored Vehicle (MIAV) to equip the new US Army Brigade Combat Teams (BCTs). The actual contract was awarded to a joint venture company called GM GDLS Defense Group. The US Army has named the vehicle Stryker.

Production is undertaken by General Dynamics Land Systems - Canada in London, Ontario and by General Dynamics Land Systems Lima, Ohio. In addition, final assembly of the Infantry Carrier Vehicle (ICV) is undertaken at the Anniston Army Depot in Anniston, Alabama.
The first LAV-III (8 × 8) vehicles in the ICV configuration were handed over to the US Army in March 2002.

TROPHY Active Protection System (APS)

TROPHY (in Hebrew: "חור ליעמ", lit. "Wind Coat") is a protective shield system for both light and heavy armored vehicles that intercepts and destroys missiles and rockets with a shotgun-like blast just before they hit. Trophy Active Defense System (ADS) is marketed by General Dynamics (GD), based on a system designed in Israel by an industry consortium headed by RAFAEL, including Israel Military Industries (IMI) and Israel Aircraft Industries Electronics (IAI/ELTA). After evaluating several systems available in the world market, General Dynamics selected the system for further improvement and is offering a version to the US Army and other customers. GD plans to introduce the system with every new and existing combat vehicle it produces, including Stryker, M-1A2 and FCS. According to GD officials, the system can be adapted to US requirements and enter production within two years. The system has completed hundreds of live tests with the Israel Defense Forces and demonstrated effective neutralization of anti-tank rockets and guided missiles, high safety levels, insignificant residual penetration and minimal collateral damage. The system is in full-scale engineering phase for inclusion on Israeli Army Merkava Mk. 4 tanks and the future light armored vehicle (Stryker).

The Trophy system has three elements providing – Threat Detection and Tracking, Launching and Intercept functions. The Threat Detection and Warning subsystem consists of several sensors, including flat-panel radars, placed at strategic locations around the protected vehicle, to provide full hemispherical coverage. Once an incoming threat is detected, identified and verified, the Countermeasure Assembly is opened and the countermeasure device is positioned in the direction where it can effectively intercept the threat. Then, it is launched automatically into a ballistic trajectory to intercept the incoming threat at a relatively long distance.

Specific details about the composition and mechanism of this explosive interceptor device are classified. From the briefing provided by US sources, Trophy is designed to form a "beam" of fragments, which will intercept any incoming High Explosive Anti Tank threat, including RPG rockets at a range of 10 – 30 meters from the protected platform. The Trophy development roadmap includes an enhanced countermeasure unit to be available in the future for protection against kinetic energy (KE) threats. Trophy was designed to effectively operate in a dense urban environment, where armored vehicles operate closely with integrated infantry forces. Therefore, direction, formation and energy of the fragments are designed to ensure effective target kill with low collateral damage and low risk to nearby troops. While not in use, the system is maintained in the stowed position, protected by armor shield. The system has an automatic reload mechanism to handle multiple attacks.

One of the main advantages of the TROPHY system is the possibility of reducing the heavy armor now required to defend vehicles. This means much lighter tanks and battle taxis that could be airlifted to future battlefields. It also opens the way to greater use of armored vehicles inside urban areas where bridges and buildings often cannot support the weight of today's heavy main battle tanks. Use of TROPHY on the Stryker vehicle will negate the need for the heavy "slat" armor, and the vehicle will be able to fit into a C-130 in full battle ready condition. Currently, "slat" armor must be removed before the vehicle is loaded into the plane and reattached at the destination. The APS seeks to eliminate this step. In addition, the newer, smaller size will enable the vehicle to negotiate urban areas currently inaccessable to a fully armored vehicle.

The system can simultaneously engage several threats arriving from different directions, is effective on stationary or moving platforms, and is effective against short and long-range threats (such as RPGs and Anti Tank Guided Missiles). Trophy is designed to be effective in open or closed terrain, including urban areas, and can be operated under all weather conditions.

NOTE: UNCLASSIFIED Video of live fire demo and briefing available is posted to the AS&C common drive O:\COMPARATIVE TESTING OFFICE / Foreign Comparative Testing (FCT) Program

NOTE: The US Army has rejected the Israeli Rafael Trophy active protection system for its 8x8 wheeled Stryker Armoured Fighting Vehicles.

Israel Military Industries (IMI)	Iron Fist Until recently, the development of Iron Fist was shrouded in secrecy, as it was developed in parallel to a different Israeli developed ADS system - RAFAEL's Trophy, which entered full scale development in 2005. However, due to rapid development pace and successful testing, IMI expects to deliver the first systems for Israel Defence Force (IDF) testing and qualifications by mid 2007.

Section 4: Miscellaneous APS Products/Services

This section describes various APS/products/services not discussed in previous sections. Table 4-1 contains companies, which provide APS products and/or services. Words in blue indicate hyperlinks to more detailed information.

Table 4-1. Companies That Provide Various APS Products/Services

Company	APS Products/Services Description
Threat Warning Devices A key component in Missile Countermeasures Devices (MCD) and Active Protection Systems (APS) is the threat warning. The most mature system is the laser warning device.	
Goodrich	VVR-2, has been deployed with USMC LAV reconnaissance vehicles since 1996, and is currently being augmented by the more advanced VVR-3, which is capable of detecting laser rangefinders, designators as well as beam-riding missiles at a 360 degrees azimuth and 55 deg. elevation.
EFW subsidiary of ELBIT SYSTEMS LTD Haifa 31053, Israel Tel: (972-4) 8315315	Threat Detection System (TDS) a multi-spectral system that can detect both laser and IR illuminators. Offering high accuracy, the system has an expanded coverage of 110 degrees in elevation and 360 degrees azimuth.
Armor Protection An APS does not totally supplant armor. Vehicle armor must still provide protection against threats that cannot be addressed by the APS. These threats include small arms, mines and explosive fragments, including the residual shrapnel effects resulting from an active protection engagement. Protection all around by passive armor is becoming too heavy for even the heaviest tanks, and even these cannot stop all threats in all directions. Therefore, a modern armor is a suite of protection means, comprising of relatively thin shell of ballistic steel and composite armor, also known as hybrid armor, designed to provide optimal protection from specific threats. Such armor can accommodate steel, various combinations and matrixes of composite materials, soft and elastic heat absorbing materials, kinetic energy (KE) absorbing materials such as ceramics, or depleted uranium and energetic materials (various explosives) that form reactive armor elements. Explosive Reactive Armor (ERA) is a common form of add-on armor, used on many AFVs. This concept is combat proven. Reactive armor utilizes add-on protection modules conforming of thin metal plates and a sloped explosive sheath, which explode when sensing an impact of an explosive charge (such as High Explosive Anti-Tank - HEAT projectile).	
The USMC is nearing completion of vehicle hardening requirements. • All Marine Armor Kits (MAKs) requirements for our base HMMWV and A2 models were achieved in November 2005. • The MTVR (7-ton truck) Armor System (MAS) requirements will be completed May 2006. • M1114 (up armored HMMWV) operational requirement will be complete in July 2006. • USMC has fielded “Cougars” or Hardened Engineer Vehicles (HEVs). • Final deliveries of Joint EOD Rapid Response Vehicles (JERRVs) scheduled for June 2006. • Army and Marine Corps working together for a mid-term solution through the M-1151/2 designed to replace base HMMWV A2 models that have reached the end of their service lives. The M-1151/2 is the bridge vehicle to a Joint Light Tactical Vehicle (JLTV) solution for the Army and Marines.	
Force Protection, Inc	Cougar JERRVs & Buffalo vehicles Force Protection manufacture Cougar JERRVs and Buffalo route clearance vehicles outside Charleston, S.C.

Table 4-1. Companies That Provide Various APS Products/Services (Continued)

Company	APS Products/Services Description
Armor Protection (Continued)	
Lawrence Livermore National Laboratory (LLNL)	Gun Truck Armor Kits Under funding from the Defense Advanced Research Projects Agency (DARPA) and in collaboration with the US Army, LLNL researchers have created a modular, easy-to-assemble armor protection kit that, with the addition of several machine guns, allows the military to convert five-ton supply trucks into gun trucks to protect convoys.
AIGIS Blast Protection, UK	Vehicle anti-mine protection. The most efficient lightweight blast protection available for vehicles. OEM or retro-fit.
Electronic Warfare As modern warfare is adapting to asymmetric warfare, so does electronic combat, which is diverging from the fixation on engagement in the vicious circle of EW-ECM-ECCM towards addressing the sophisticated, commercial communications and electronic systems, currently used by terrorists and insurgents. The new threat systems range from devices used maintaining loose control over a diversified network of collaborators to the employment of sophisticated IEDs triggered by cellular phones and used as remote controls. Several systems developed to combat these threats were introduced at Eurosatory 2006.	
Tadiran Electronic Systems Israel Subsidiary of the Elisra Group	Cellular SIGINT and EW systems In contrast to common use of "brute force" jamming, in the attempt to disrupt communications or isolate a suspected IED from the cellular network, the new system employs selective jamming, therefore enabling continued operation of friendly units while incapacitating suspected or unidentified cell-phones. When specific sets are identified as "suspects", they can be individually intercepted, localized and deactivated by the use of Elisra's hand-held passive Locator, which can lead intervention forces to the suspect source, or the intervention force can use the Cellective, a selective cellular jammer to deactivate the suspected device even without locating it. 
Diehl and Rheinmetall Defense	High Power Electro-Magnetics (HEPM) The HEPM system can be effective against roadside bombs and IEDs containing electronic devices (such as a cell phone or any other electronic actuating device). An HPEM based counter IED system can cause controlled explosion or deactivation of the charge at a safe distance from the protected vehicle. Different systems developed by both companies will offer ultra-wideband HPEM coverage, from Megaherz to Gigaherz, effectively denying all types of communications with either directional or omni-directional coverage.

Table 4-1. Companies That Provide Various APS Products/Services (Continued)

Company	APS Products/Services Description
Electronic Warfare (Continued)	
EDO Communications and Countermeasures Systems (CCS) Simi Valley, CA	Shortstop Electronic Protection System (SEPS) System is programmable and responsive to selected RF threats. SEPS is designed to pre-detonate RF proximity fused battlefield munitions, such as modern artillery shells, at a safe distance from their designated target. In use by the US Army, SEPS is produced in three configurations – man-pack, vehicle mount or stand-alone. 
Netline Communications Technologies Ltd 2 Kaufman St., Textile House Tel Aviv ISRAEL, 68012 Telephone: 03-5109855 Specializing in electronic warfare and cellular jammers, the company develops state of the art high-tech solutions, mainly for military, anti-terror units and homeland security needs.	C-Guard VHP ECM Designed to defend military convoys and police Explosive Ordnance Disposal (EOD) teams against remote controlled improvised explosive devices (RCIED) used by terrorists, The C-Guard VHP ECM effectively jams the signals of radio transmitters used to remotely activate explosive devices and bombs. It's being used by NATO, the US Department of Defense, as well as many military and police forces around the world.  C-Guard VHPs are designed for fixed or vehicle installation. But jamming is only one of Netline's talents. With a slight modification, cell phones become high-quality bugs. An owner can call the phone from anywhere in the world without it emitting a ringing tone while its screen remains blank, apparently turned off.
Unmanned Ground Vehicles To increase standoff from IED blast effects, the USMC have equipped Explosive Ordnance Disposal (EOD) units and Combat Engineer Battalions with a host of robots to enhance force protection measures. Examples consist of the Marcbot for engineer Intelligence Surveillance and Reconnaissance (ISR) use and the Talon, Packbot, Bombot, and RC-50 for EOD operations.	
iRobot Corporation 63 South Avenue Burlington, MA 01803 Phone: 781.345.0200 iRobot designs behavior-based, artificially intelligent robots. Powered by iRobot's proprietary AWARE™	iRobot PackBot EOD is a rugged, lightweight robot designed to assist with Explosive Ordnance Disposal (EOD), can handle a full range of Improvised Explosive Device (IED) and conventional ordnance disposal challenges. Its lightweight, ruggedized OmniReach Manipulator System can reach as far as 2 meters in any direction to safely disrupt difficult-to-access IEDs, military ordnance, land mines and other incendiary devices. This versatile robot quickly adapts to different IED, conventional ordnance and SWAT missions.

Table 4-1. Companies That Provide Various APS Products/Services (Continued)

Company	APS Products/Services Description
Unmanned Ground Vehicles (Continued)	
Carnegie Mellon University and BAE Systems (partners)	Gladiator USMC is procuring the Gladiator. It is being designed as the first type classified tactical ground robot to be delivered to the US military. This capable system will enable remote combat scouting, assault, and reconnaissance, surveillance, and target acquisition tasks in order to neutralize threats and reduce the exposure of individual Marines to hostile enemy action
Miscellaneous	
DRS	Driver's Vision Enhancer (DVE) B-kit  DRS's Driver's Vision Enhancer (DVE) B-kit provides combat and tactical-wheeled vehicle operators with unparalleled flexibility to conduct day/night operations or maneuver in severely degraded visual conditions caused by smoke, fog, dust or other battlefield obscurants. The DVE B-kit provides situational awareness, vehicle tracking, support elements for the combat force, and gives an operator the ability to detect targets, Improvised Explosive Devices (IEDs) or ambushes.

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Active Protection Systems (APS) Programs

System	Description	Program Status	Technical Characteristics	Background Info	Contractor / Location
Close-In Countermeasure (CICM)	developed as near-term countermeasure against RPG threats encountered in Iraq; modular, lightweight, low-cost, designed as adaptable to wide range of ground, sea, air platforms	developed in 2004; in 2005 successfully completed first on-the-move test against incoming Rocket Propelled Grenades (RPGs) at government test range; system mounted on moving Bradley vehicle	uses passive cueing sensors (flash detector) and low-cost tracking radar to detect and acquire potential threats at close ranges; once an incoming threat is identified, the system points to its direction, and launches a barrage of 55 pellets, forming a "wall" of steel in direction of threat 10m from protected vehicle; pellets are designed to loose energy rapidly minimizing collateral damage to nearby troops, or bystanders, and self-inflicted damage to protected platform is avoided; system traverses over 180 deg. and is loaded with 2 bi-directional units for full hemispherical coverage, allowing for 2 shots in each 180 sector; system can be manually reloaded after attack; weight of operational system expected at 200 kg	Considered a derivative of IAAPS; developed in only 2 years using internal R&D funds to respond to near-term operational needs; dev. team included BAE Systems (Santa Clara, CA, Nashua, NH), Curtiss-Wright Controls, Pacific Scientific	BAE Systems, Santa Clara, CA
Trophy Active Defense System (ADS)	creates hemispheric protected zone around vehicle where incoming threats are intercepted & defeated; has 3 elements: threat detection & tracking, launching, & intercept; designed to operate in dense urban environment where armored vehicles operate closely with integrated infantry forces; direction, formation, & energy of fragments designed to ensure effective target kill with low collateral damage & low risk to nearby troops	adapted to US requirements and enter production within 2 years; completed hundreds of live tests with the Israel Defense Forces & demonstrated effective neutralization of anti-tank rockets and guided missiles, high safety levels, insignificant residual penetration, and minimal collateral damage;system in full scale engineering phase for inclusion on Merkava Mk 4 tanks and Stryker vehicles; March 2006 GD announced successful completion of firing test, requested by OSD-OFT in support of Project Sheriff (aka Full-Spectrum Effects Platform (FSEP), to validate Israeli Army's tests that demonstrated Trophy's ability to detect, track and destroy incoming RPGs at safe distances from host vehicle	threat detection & warning subsystem consists of several sensors, including flat-panel radars, placed at strategic locations around protected vehicle, to provide full hemispherical coverage; when incoming threat is detected, identified, verified, the countermeasure assembly is opened, the countermeasure device is positioned in direction where it can effectively intercept threat; CM is launched automatically into ballistic trajectory to intercept incoming threat (HEAT, including RPG rockets 10–30m range) at relatively long distance; system maintained in stowed position when not in use & protected by armor shield; has automatic reload mechanism to handle multiple attacks; simultaneously engage several threats, arriving from different directions; effective on stationary or moving platforms & against short and long range threats	marketed by General dynamics; based on system designed in Israel by industry consortium headed by RAFAEL; GD plans to introduce system with every new & existing combat vehicle it produces, including Stryker, M1A2 & FCS	RAFAEL Armament Development Authority, Ltd. (system); IAI Elta (threat detection), Israel; General Dynamics Land Systems and Rafael entered into a teaming agreement in 2005 to introduce Trophy in the US for possible integration on ground vehicle fleets
Omni-Directional Panoramic Tank Camera	provides continuous coverage of 360 deg. FOV without rotation, provides entire vehicle's crew with real-time awareness of vehicle's surroundings and potential threats outside vehicle	Unknown	patent pending omni-directional optics provides continuous 360 degree field of view without rotation mechanism; equipped with video motion detector programmed to selected areas of interest, providing real-time alerts; system utilizes high resolution digital camera mounted on mast placed on rear part of upper turret; system feeds processed images to computerized display installed in tank	none	ODF Ltd., Israel

Close-Range Active Defense (CARD)	means for active protection of armored fighting vehicles threatened by infantry and anti-tank weapons at close/medium range; delivers fragments at close range & behind protection	low rate production for testing by late 2004; production and delivery by mid-2005	uses controlled fragmentation technology (already implemented in 81/60mm MAPAM (Mortar Anti-Personnel Anti-Material bombs)) which guarantees all fragments are same size and energy, contributing to increased lethality and well defined safety zones (for accompanying troops); each CARD is launched from standard smoke launchers to range of 35m & programmed to burst at height of 2-7m above surface, generating over 1,000-0.3g fragments	none	RUAG, Emmen, Switzerland
AWiSS program	designed to defeat RPGs & other anti-tank munitions fired from close range, as well as standoff AT missiles; offers significant reduction of a Kinetic Energy (KE) projectile's penetration capability	currently funded by R&T contract of the Federal Office of Defense Technology and Procurement; system could be available on market in 2-3 years	designed as lightweight suite, adaptable for protection of heavy and light vehicles; system comprised of search and track Ka band radar, capable of operation in low visibility conditions; after detecting threat by radar, directional countermeasure unit is rapidly traversed, at rapid slewing rate (over 600 degrees/sec.) aiming in general directional of threat; target is handed over to launcher-mounted sensor which performs ballistic calculations for final intercept; each launcher has 3-4 canister launchers that fire grenades ahead of vehicle in direction of incoming threat; provides 360 deg. Coverage, weighs 400kg; system adds 400mm elevation above armor, requires additional 400mm clearance under armor; uses 3kg grenade which can engage AT missiles/rockets; response rate of 355ms, detecting incoming threats at range of 75m & engaging them with grenade at range of 10m from target	recent operational test conducted July 2006 deployed on a Leopard 2 MBT, demonstrated to high-level German military, MOD representatives, international delegation, successfully defeated rapidly approaching MILAN AT missile	Diehl BGT Defence (System Integrator), Germany
Laser Induced Plasma Channel (LIPC)	designed to be installed as corridor or passageway denial system; employed at indoor or outdoor locations and configured for each individual installation's security requirement	unknown	creates laser guided electric barrier initiated automatically from existing customer-supplied computer system that identifies authorization of the person (similar to conventional keyless entry systems) or via operator command; designed to stop intruders in passageway or at vehicle checkpoint with lethal/non-lethal electrical discharge	technology has been used for a Portal Denial System	Ionatron, Tucson, AZ
Multilayer Active Protection System	designed to protect convoys, vehicles, and buildings from various types of threats, e.g., snipers, RPGs, etc.	company has engaged in preliminary studies	proposed system consists of four layers: (1) "the dazzler," consuming less than 1Kw, powered from standard 12v vehicle battery, designed to engage potential threats within 200-500m range and disrupt weapon's aiming capability; will be integrated with surveillance system that will spot potential threats by employing a Gesture Recognition image processing System (GRS); (2) second layer consists of directional, laser-assisted electric pulsed effect (UV laser which ionizes the air to enable effective conduction of an electrical pulse 30-100m. The pulse will disrupt the electronic elements of the incoming missile and could also trigger it to explode immaturely; (3) "burning laser," a high-power (1.5 - 3Kw) IR laser, which will focus on vulnerable elements of incoming threat (ogive, fins, etc); (4) Kinetic Resonance Energy Weapon (KREW), hydrogen powered vortex cannon which generates directional shockwaves in direction of threat, used on any threat that penetrated through outer layers, deflect missiles or stop shrapnel from hitting protected site		XADS (Xtreme Alternative Defense Systems), Anderson, IN
Full Spectrum	designed to provide primary	new active-protection	system's components will include threat detection, tracking	none	United Defense (now

Active Protection (FSAP)	survivability component of future armored vehicles, protecting vehicle from missiles, KE threats and top attack; system detects, tracks, intercepts and physically defeats large-caliber threats at distance sufficiently far from defended vehicle to reduce lethal effects of threat and assure vehicle survival	concept currently developed for the US Army for future and current armored vehicles	systems, signal processing systems, countermeasures systems and base armor used for structural and residual threat defeat; will utilize multiple sensors, including radar, IR and laser detection systems; upon threat detection system will enable deployment of countermeasures or defensive tactics to avoid hit (when engaging AT missiles or threats at medium/long range), or automatically activate countermeasures, when necessary (primarily against high velocity missiles and KE threats or RPGs at short range); development of enhanced commander's decision aid (CDA) is also being pursued under FSAP; system will feed from vehicle's sensors, as well as off-board data sources, and will rapidly process information, classify threats, and recommend appropriate countermeasures		BAE)
Full Spectrum Active Protection Close-In Shield (FCLAS)	provides an autonomous, fast reacting countermeasure against incoming threats (e.g., RPGs, AT missiles, HEAT ammunition (CE)	under development at US Army Tank Automotive R&D and Engineering Center (TRADEC); development supported by US SOCOM and DOE; prototype system anticipated in 2004 and operational system by 2005	comprised of sensor and short range grenade launcher, loaded with special fragmentation grenades with delay fuses set to intercept incoming threat at approx. 5m range from protected vehicle; actual initiation of explosive charge is triggered by side looking RF proximity fuse which senses incoming projectile as it passes nearby; explosion forms vertical, doughnut shaped fragmentation effect that kills passing threat but does not affect protected vehicle; target weight is 140kg. to enable deployment on light vehicles; each grenade is equipped with forward looking radar mounted on exposed tip of grenade	subset of FSAP; used to protect armored and unarmored vehicles, naval vessels, helicopters; other utilization options include protection of fixed locations, including military posts, buildings, soft targets (e.g., tents, oil and gas tanks); awarded among the US Army Material Command's "10 greatest inventions for 2002"	Archangel Defense Systems, Virginia, USA
Multifunction Self Protection System (MUSS)		prototype system currently under development at KMW and EADS under a technology evaluation of the Federal office of Defense Technology & Procurement (BWB)	weighs 65-160kg depending on equipment application; uses combination of 4 sensors each covering an arc of 95x70 deg. with a resolution of +/- 1.5 deg.; sensors employ UV missile launch signature and laser detectors; when threat is detected, system responds within 1–1.5 sec. activating smoke screen or directing infrared jamming signal toward launching platform; during testing integration was designed for BOXER, FENNEK, PUMA, & Leopard 2A5 vehicles	during test phase, system was mounted on Leopard 2 tank which successfully defended itself against various missile threats	Krauss Maffei Wegmann (KMW), Germany / EADS
KBCM	modular countermeasure kit designed for mounting on modern armored fighting vehicles	developed by the French Army	utilizes a DAL laser warning system and DDM missile launch detection system; smoke countermeasures and electro-optical IR jammer modulated to jam missile operator's deviation sight	considered for mounting on Leclerc, AMX-30B2 tanks, and AMX-10RC, VBCI APCs	GIAT (System Integrator), France
Missile Countermeasure Device (MCD)	MCD is used as part of a comprehensive warning and threat response ECM system, which detects and intercepts laser signals indicating an imminent attack.	Since 1991, as lessons learned from Desert Storm, some platforms received electro-optical (IR) jammers; the US Army fitted the Loral VLQ-6 MCD (aka HardHat) & Sanders VLQ-8As on M-1A1 & M-2/3 Bradleys	system emits IR signals to disrupt threat's missile /command unit tracking loop; MCDs typically mounted high above turret and scan frontal arc to detect and decoy away most widely used ATGMs; is also integrated with M6 countermeasure device which launch smoke and flares		Unknown, U.S.A.
Cerberus	laser warning defensive aid system for AFV systems	unknown	uses 4 detector arrays and 16 launchers covering front and rear; other configurations incorporate 7 sets of sector arrays (6 in azimuth, 1 in elevation) to cover entire hemisphere; detectors are sensitive to all types of lasers (400–1600 nm); warning system triggers various alarms, such as "single pulse lasers" (rangefinders), "multi-pulse		Thales Optronic Systems

			lasers" (target designation) and "overhead laser" (top attack); automatically activates appropriate countermeasures from 66/76mm grenade dischargers, such as forming smoke screen over an arc of 180 deg. within 2 secs.		
Active Protection System	protective textile that instantly becomes rigid upon impact, but remains flexible and breathable when protection not required		under normal conditions, crosslinking bonds of the fabric's dilatant silicone coating open and re-form easily, keeping material soft and flexible; under sudden impact, these bonds are unable to open, material resists the force and instantly becomes rigid; effect only lasts for duration of impacting force, after force has dissipated through dilatant/fabric construction, the silicone immediately becomes soft and flexible again; fabric uses spacer yarns to create 3D structure designed for optimal absorption of impacting force; fabric's surface coating and spacer yarns in immediate impact area instantly become rigid and transmit energy to adjacent spacer yarns, thus absorbing and distributing energy away from impact site; micro-engineering provides maximum protection & leaves system lightweight, flexible and completely breathable	versatile, durable, lightweight; can be incorporated directly into a wide range of products to provide high levels of safety	Dow Corning
Shtora-1	electro-optical jammer that jams the enemy's semiautomatic command to line of sight (SACLOS) antitank guided missiles, laser rangefinders, & target designators; is actually a soft kill, or countermeasures system	first known application of the system is on the Russian T-90 MBT that entered service in the Russian Army in 1993	Comprised of 4 key components: electro-optical interface station, which includes a jammer, modulator, and control panel; bank of forward-firing grenade dischargers mounted on either side of turret capable of firing grenades dispensing an aerosol screen; laser warning system with precision and coarse heads; control system comprising control panel, microprocessor, and manual screen-laying panel which processes information from sensors and activates aerosol screen-laying system.	most effective when used in tandem with a hard kill system such as Arena; system was shown fitted to a Russian T-80U and Ukrainian T-84 MBT at International Defense Exposition (IDEX) held in Abu Dhabi in 1995	Unknown, Russia
Arena	intended to protect tanks from AT grenades, ATGMs, topattack munitions, including ATGMs launched from aerial platforms; developed by Russia (~1993); Russians have demonstrated system to Germans and French, and reported to have performed as advertised	remained at prototype stage (mid-1997) and understood not to have completed its developmental phase; expensive system, around $300,000 per copy	computer system automatically activates active defense system with reaction time of .05 secs; fully automatic and provides high degree of protection through 300° with dead area to rear of turret; in combat mode, multidirectional radar mounted on MBT roof constantly scans for approaching ATGMs and locates any target approaching within 50m of tank within designated speed band; radar operates in target-tracking mode, locking onto target 7.8-10.06m from tank; after processing data computer selects countermunition (CM)- protective ammunition housed in 20 silos around turret, and fires small projectile (similar to Claymore mine) into path of approaching ATGM; ammunition detonates 1.3-3.9m from target generating directed field of destructive elements which destroy/disable target to levels no longer dangerous; system ready to repel next target after .2-.4 secs.		Unknown, Russia
GALIX System	countermeasure system mounted on the French Leclerc MBT		consists of electrical control unit and launching tubes set into turret rear & provides 360° protection; fires 80mm smoke rounds, anti-personnel rounds, or decoy rounds out 30-50m in single rounds or salvoes; reaction time less than 1s; smoke round can produce smoke screen that includes visual and multi-band screening agents, over an arc of 120° to front of vehicle, screen can blind any optically or IR-controlled weapon system; IR decoy deviates the trajectory of antitank missiles controlled by an IR seeker; operated	reported to protect Leclerc against any known weapon on battlefield	Unknown, France

			from top of vehicle, is efficient for more than 10secs; major shortfall of the Galix system is the lack of an LWR to alert crew and automatically cue system		
Laser Warning System 2 (LWS-2)	advanced threat warning system; system provides alert whenever optical radiation is aimed at vehicle from any direction and warns against possible enemy presence and attack intentions in real time.	production	indication includes type of radiation, such as IR searchlight, laser rangefinder, or laser designator	Merkava 3 is believed to be first MBT fitted with threat warning system as part of its standard production	Unknown, Israel
POMALS	advanced threat warning system	prototype stage.	features LWS-2 that identifies incoming radiation emitted by laser designators/rangefinders, IR sources; 60mm launch tubes are mounted on turret to fire wide variety of munitions that produce countermeasure options including visible/IR smoke grenades, chaff/flare decoys, HE/antipersonnel grenades, special munitions; can be upgraded to incorporate an IFF system	operates similarly to Shtora-1; designed as an add-on or retrofit package	Unknown, Israel
Passive Approach Warning System (PAWS)	locally developed self-protection suite designed to fend off man-portable, heat-seeking missiles for Cobra and Apache gunships	operational testing of PAWS expected to continue through late summer (2004) after which system will be certified for fleet-wide deployment	uses IR imagery and signal processing to detect and track incoming missile's hot plume; tells how threatening a particular missile is by analyzing its flight path. If missile is determined to be a threat, PAWS sends warning signal to aircrew, fires off chaff and flares, and hands data to aircraft's other avionics and electronic warfare systems	will likely be installed on other helicopters- particularly troop transports, whose missions bring them into contact with shoulder-launched, short-range infrared (IR) missiles increasingly deployed by insurgency forces in low intensity conflicts; a fighter version called PAWS-2, is being produced for the Israel Air Force's 102 new F-16I aircraft	Elisra Electronic Systems, Israel
Quick Kill	using FCS's sensors and common radar, this APS detects, tracks, and defeats enemy threats with precision munitions	awarded contract worth up to $70M from BAE Systems; base program lasting from March 2006 to September 2011; in February 2006 system brought down an RPG surrogate in a test at the Energetic Materials Research and Testing Center of the New Mexico Institute of Mining and Technology near Socorro, N.M	System has two parts: Option A: designed to blunt short-range RPG attacks and bring down incoming projectiles 3-20m away; slated to arm Stryker wheeled vehicle and other armored vehicles; slated to enter production in 2011; solid-state phased-array radars mounted on each of vehicle's four corners scan for incoming weapon, when grenade crosses 200m threshold, computer calculates its trajectory and answers several logic questions, if all conditions are correctly met, computer calculates intercept course for defensive munitions and programs it within 20msecs; munition pops straight up from one of quartet of 4-round launchers, thrusters jet it toward intended intercept point, and rocket motor ignites to accelerate it back down towards incoming weapon; forward-firing warhead then detonates showering RPG with 30 deg. cone of fragments rendering it inert Option B: augments this short-range defense with longer-range system that detects incoming high-explosive tank rounds and top-attack mortar shells up to 2,000m away; destroys them up to 200m out by firing missile with semi-active seeker; slated to equip first prototype FCS ground vehicles and enter production in 2012	system will form part of a larger integrated Hit Avoidance System of electronic countermeasures being developed for FCS to include smoke launchers, laser warning receivers and jammers	Raytheon's Network Centric Systems Division, Plano, TX as subcontractor to BAE Systems (the FCS hit avoidance integrator); Boeing and partner Science Applications International (SAIC) are Lead Systems Integrator for FCS

Iron Fist Active Protection System (APS)	system uses radar sensor to detect threats, and when threat is identified as imminent, an explosive projectile interceptor is launched toward it; the interceptor is designed to defeat the threat using only the blast effect to defeat the threat	expect to deliver first systems for IDF testing and qualifications by mid 2007; IMI and Elta Systems (developer of the search-and-track radar) have contributed their own funds for prototype development and testing; MoD and military sources state system will require at least $25M and another 2 years to bring it through full scale development, approval to proceed beyond current prototype phase unlikely without outside investment	system consists of search-and-track radar (4 antennae installed on each corner of vehicle), internally installed command-and-control unit, and two electrically powered launchers positioned at platform's front and rear; when radar detects target, sensory data feeds into central control unit that measures flight path, classifies target as approaching threat, and then automatically activates a launcher, each of which contains 2 blast warhead interceptors; for RPGs, mortars, and other exploding threats, the interceptors release a blast in close proximity to approaching threat, at a far enough distance to prevent damage or injury to vehicle and crew, blast generates shock wave that destroys threat without initiating its warhead; with KE rounds, the shock wave generated by the interceptor blast changes the angle of attack, creating a yaw effect that significantly degrades its penetration capabilities; the interceptor is made of combustible envelope, fully consumed in the explosion, without the risk of shrapnel; provides effective, close-in protection for vehicles operating in dense, urban environments; the sensor provides essential input to situational awareness systems, based on ground radar surveillance, moving target detection, classification and tracking and motion detection; by loading other types of projectiles (i.e., nonlethal, anti-personnel, smoke or illumination) the system can be used in support of routine operations	can be installed on light vehicles, trucks, Humvees, offering effective protection from RPGs; system has growth potential to protect sensitive elements of fixed installations or patrol boats from RPG attacks, frequently encountered in counter insurgency operations	Israel Military Industries (IMI) supported by Israel's MoD Directorate for Defense Research & Development (DDR&D)
Integrated Army Active Protection System (IAAPS)	programmed to intercept threat at long range by detecting launch signature of missile or tank gun firing; after detection system attempts to disrupt missile's guidance by IR countermeasures, if attempts fail, the hard-kill module is erected, detects the incoming target, and traverses to point the countermeasure rockets at incoming target; projectile is launched in direction of incoming threat to intercept and destroy it at a 30m distance from protected vehicle	US Army's TACOM demonstrated the defeat of 3 new categories of AT threats (February 2003); system was on track for FCS Block 1; September 2003 TACOM began new series of tests on a combat vehicle defeating live threats while traveling at 20 mph, tests expected to continue through 2005	uses integrated soft and hard-kill measures, passive (EO) and active (radar) sensors, soft kill countermeasures (IR jammers, decoys), and hard kill active protection system devices; designed to protect armored vehicles from direct fire and top attack threats with growth potential for KE threat defeat; classifies inbound threats and assigns right countermeasure to defeat it; suite incorporates an EW system delivered by BAE Systems and an active protection system developed by Northrop Grumman Space Technology, linking to United Defense's platform survivability processor	future growth of IAAPS includes incorporation of objective active protection counter-munitions for hardened threats and specifically large caliber long rod penetrators	United Defense Industries (now BAE)